Understanding the Operations of the Indian Dairy Industry- A Case Study

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ABSTRACT

Background: Dairy industry is one of the largest and fastest growing industry in the world. This industry faces challenges regarding lack of quality and low productivity. Large amount of fresh water is consumed and wastewater is generated in this industry.

Methods: To study about the functioning, operations, management and consumption of resources in the Indian dairy industry, three dairies situated in major cities of Maharashtra, India- Dairy A in Jalgaon, Dairy B in Pune and Dairy C in Mumbai are selected. Site visits and interviews are done to collect the extensive and holistic in-time data.

Result: Large quantity of milk is processed and various milk products are manufactured in each of these dairies. Fresh water consumed by different dairies varies between 5-6 LLPD. Enormous amount of wastewater is generated at the different stages in the milk processing and at various sources such as at milk receiving stations, in manufacturing of milk products and in cleaning and washing of equipment, tankers and floors. Average 900 KW/day of energy is spent for the effluent treatment in these dairies. Dairy A and B uses briquettes as an alternative energy source for the boiler while dairy C adapts solar as alternative technology. Minimisation of waste and utilisation and recovery from the waste can certainly help to improve productivity and reduce environmental footprint along with the growth and progress of this industry as well as country's economy.

Key words: Dairy industry, Dairy products, Energy consumption, Environmental footprint, Wastewater generation, Water consumption.

INTRODUCTION

Dairy industry grows with the growing population. It is amongst the largest and fastest growing markets in the world (Mani and Beillard, 2022). Indian dairy market had reached a value of INR 13,174 billion in 2021 (IMARC, 2022). It is expected to grow at CAGR of 14.98% during year 2023-27 (IMARC, 2022). Dairy activities form an essential part of the rural Indian economy serving as an important source of employment and income. It is the single largest agricultural commodity which contributes 5% to the national economy of India, witnessing 6.4% (CAGR) in the past 5 years (FICCI, 2020). The Indian dairy industry also serves as a tool of socio-economic development along with offering the profitable business opportunities. Keeping this in view, the Government of India has introduced various schemes and initiatives aimed at the development of the dairy sector in the country (Heema *et al*., 2022). In June 2020, Government of India in association with the Department of Animal Husbandry and Dairying has announced infrastructure development fund worth $ 2.1 Bn to promote investment by private players and MSMEs in dairy, meat processing and animal feed plants which in return is expected to create 3.5 million jobs (IMARC, 2022).

The milk processing capacity in the country has increased over the years due to increase in demand of good quality, hygienic and packaged milk and milk products (Lyngkhoi *et al*., 2022; Zirmire and Kulkarni, 2019). By volume, India is currently ranked the largest milk producer in the world, contributing to 13% of worlds total milk production (IMARC, 2022). Large Indian cattle population is the reason for high milk production in India rather than the good milk yields (FICCI, 2020). The milk production per animal is significantly low as compared to the other major dairy producers like USA, Germany, France and New Zealand (FICCI, 2020. Even the cost of milk production is lowest in India and hence it has an edge in the production of milk over the other countries in the world (IMARC, 2022). Out of the total milk processed in the country, 65% to 70% is sold as liquid milk (FICCI, 2020). This is due to the large amount of direct consumption of liquid milk by the producer households. The remaining rest is processed into various

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dairy products. The demand for processed dairy products has increased with the growth of income levels and this have left little dairy surpluses for the exports (Intodia, 2017). Despite being the largest milk producer in the world, India has made it to only 1% of the global dairy products trade (FICCI, 2020). Owing to this, the Indian dairy industry holds tremendous potential for growth and value-addition.

Dairy industry faces challenges regarding lack of quality and low productivity as major part of the market is unorganised (Kumar *et al*., 2018). The major setback for India is the high cost of conversion to dairy products which might be due to lack of scale at production and processing level (FICCI, 2020; Prabhakar *et al.,* 2015). In the past few years, the unorganised sector comprising of farmers and cooperatives contribute maximum to the dairy market. The organised sector has to catch up with them thus meeting the needs of the end customers regarding the customised dairy products (IMARC, 2022). Over the past few years, attracted by the size and potential of the Indian market, the private participation in the Indian dairy sector has also increased. The focus is been given to the value-added products such as cheese, yogurt, probiotic drinks, *etc* (Wasnik and Changade, 2015). They are also introducing innovative products keeping in mind the specific requirements of the Indian consumers. These players are also improving their milk procurement network which is further facilitating the development of the dairy industry in India.

After viewing the growth potential of the dairy industry, field survey of three well known co-operative Indian dairies situated in different cities of Maharashtra, India- Dairy A in Jalgaon, Dairy B in Pune and Dairy C in Mumbai is carried out in this work in 2021-2022. After the field visit, interactions with the in-charge personnel, observations and details collected through the intense questionnaire from all the 3 dairies, enough realistic quantitative and qualitative data is collected. This data is quantified and analysed at the Institute of Chemical Technology, Mumbai. It helps to understand the entire dairy operations, processing, manufacturing, storage, distribution of various dairy products and factors to be dealt to improve the dairy productivity. Details about processing of milk; production, packaging and supply of various dairy products; water and energy consumption and wastewater generation are investigated and reported here.

Process flow in dairy plants

Dairy plants found all over the world vary tremendously in their size and types of the products manufactured. This makes it hard to give their common general characteristics. The below Fig 1 adapted from FAO website, represents the generalised process flow observed in Dairy A, Dairy B and Dairy C.

Production details

The dairies selected for the survey are serving the people from past 30-40 years and have turnover in the range of 500-700 crores. Dairy A, B and C have 6, 8 and 6 milk

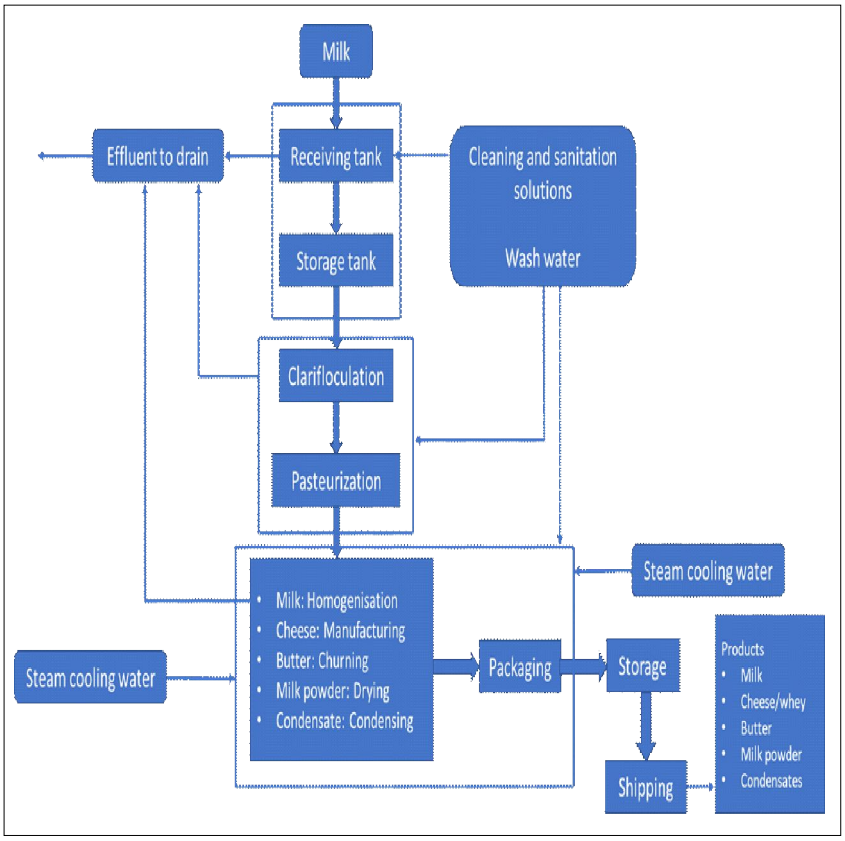


Fig 1: Generalised workflow in dairy industry.

collection centres at the taluka level respectively. The below Fig 2. shows the milk handling capacity of different dairies. Highest average milk processing capacity of 4LLPD is observed for Dairy C located in Mumbai. Dairies do not operate to the maximum of their capacity. There is always scope of processing more milk as the demand for it increases in the coming years.

The water consumption by various dairy products in dairy A is given in Fig 3. It indicates that the maximum water is required for manufacturing of Skimmed Milk Powder (SMP) with ~5 Litres/ Kg of SMP produced followed by 2.7 litres/ litre of processing milk and various other dairy products.

Table 1 indicates that all the 3 dairies have huge amount of production capacity and they manufacture variety of dairy products. The huge amount of production obviously leads to massive amount of water and energy consumption, wastewater and product waste generation, leaving a huge footprint on the environment.

Supply details

Details of supply of cow milk and buffalo milk products are as shown below in Table 2 and Table 3 respectively. Each of the dairy supplies huge amount of milk and various dairy products in different types of packaging such as pouches, glass bottles, polypack, cups, petjars, bag, box, wrappings *etc*. There is no such provision of recollection of these packaging from the consumers and reuse and recycle them. Milk is the highest supplied followed by the plain butter milk, table butter, lassi, SMP, ghee, dahi etc in Dairy A and B. Dairy C doesn't supply numerous cow milk products, it only supplies cow milk-34,17,810.5 litres, cow ghee-8500 litres, flavoured milk-13700 litres.

Waste production

Dairy industry does not produce large amount of solid waste. The major solid waste produced from the dairy is the sludge resulting after the purification of wastewater. In aerobic

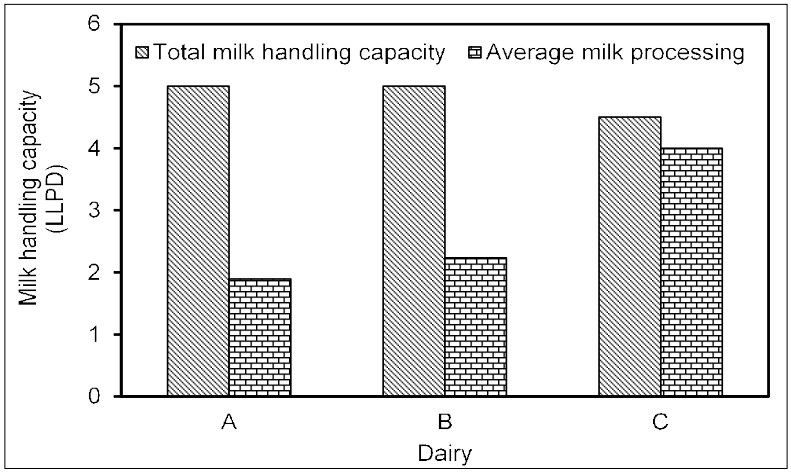


Fig 2: Milk handling capacity of different dairies.

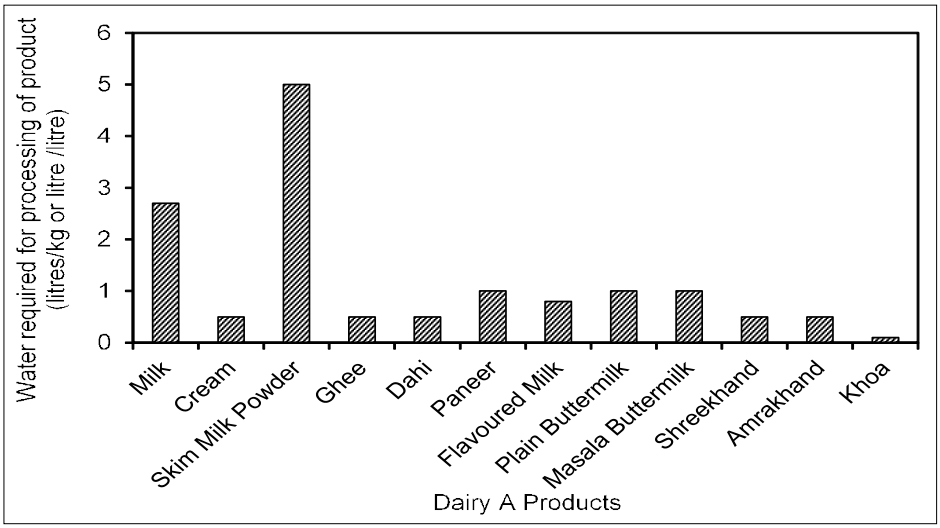


Fig 3: Water required by dairy A for manufacturing various products.

Table 1: Production capacity of various dairies.

Products	Dairy A	Dairy B	Dairy C
Milk	5 lakh LPD	2 lakh LPD	4.25 lakh LPD
Lassi	2000 LPD	1200 litres/shift	5000 LPD
SMP	15 MT/day	NA	NA
Ghee	5 MT/day	800 litres/shift	1600 LPD
Dahi	4000 LPD	NA	1000 kg/day
Flavoured milk	1200 LPD	480 bottles/shift	16000 LPD
Plain butter milk	2400 LPD	15000 LPD	3000 LPD
Masala butter milk	2400 LPD	100 LPD	2000 LPD
Shreekhand	400 kg/day	420 kg/shift	400 kg/day
Amrakhand	100 kg/day	420 kg/shift	200 kg/day
Paneer	1500 kg/day	350 kg/shift	150 kg/day
Pedha/Katli	40 kg/day	400 kg/day	NA
Khoa	40 kg/day	250 kg/shift	NA
Cream	NA	1000 kg/day	NA
Butter	NA	300 kg/shift	NA
Ice cream	NA	1600 kg/shift	NA

Table 2: Details of supply of cow milk products.

Product details	Dairy A (per month)	Dairy B (per month)
Milk	Toned milk-7,50,000 L	Toned milk-3,22,200 L
	Cream milk-21,00,000 L	Cream milk-2,36,600 L
Lassi	15000 L	340.89 L
Skimmed milk powder (SMP)	1000 kg	NA
Ghee	35000 kg	227000 kg
Dahi	10000 kg	888790 kg
Paneer	NA	153150 kg
Table butter	3000 kg	51410 kg
Flavoured milk	NA	266200 L
Plain butter milk	240000 L	NA
Masala tak	15000 L	NA
Shreekhand	NA	98940 kg
Amrakhand	NA	91630 kg
Kadhi tak	NA	2688.38 L
Pedha/Katli	NA	159900 kg
Ice cream	NA	297180 kg

Table 3: Details of supply of buffalo milk products.

Product details	Dairy A (per month)	Dairy C (per month)
Milk	Toned milk-4,50,000 L	NA
	Full cream milk-15,00,000 L	
Cream	NA	NA
Lassi	NA	97,700 L
Skimmed milk powder (SMP)	75000 kg	NA
Ghee	35000 kg	NA
Dahi	NA	5600 kg
Shrikhand	6000 kg	3000 kg
Amrakhand	5000 kg	55500 kg
Paneer	7500 kg	2500 kg
Plain butter milk	NA	78,000 L
Masala butter milk	NA	29,500 L
Khoa	1000 kg	NA
Pedha/Katli	NA	NA
Icecream	NA	NA

system, about 0.5 kg of sludge is produced per kg of COD removed while 0.1 kg is produced in anaerobic system. Different dairy industry product produces wastewater of varied compositions. It originates from the sources as shown in generalised workflow diagram in Fig 2. Dairy management practices highly influence the generation of product waste in dairy. Water consumption, wastewater generation and operation processes are the indicative of the management quality. The major wastewater is generated in washing during the production of various products and in manufacturing of cheese and paneer in the form of whey. Malfunction or breakdown of certain equipment causes milk spillage. Well controlled process reflects good management skills while bad practices reflect poor management. Good management practices produce wastewater below 1 kg/kg of milk and BOD below 1 kg/ton of milk while poor management may raise these values upto 3. Working on various factors such as better house keeping practices, efficient water control practices, supervision and suppressing of operations contributing to either the volume or BOD of wastewater is required. Monitoring and working towards extent of spillage, pipe-line leaks, pump seals, carton breakage, product damage in packing, stacking and cooler operations will also help. Proper practices needs to be followed during handling of whey, to reduce the spilled curd particles in manufacturing of cottage cheese and reduce the amount of water consumption and wastewater generation. Processes should be developed to segregate and recover milk solids from the rinses. The management attitude towards waste generation and handling should be revised.

Water consumption and wastewater generation

The total quantity of fresh water consumed by different dairies is different as shown in Fig 4. The water required in manufacturing, storage and packaging process by Dairy A and B is 3.5 LLPD and 2.45 LLPD respectively. In drinking and other basic human activities, dairy A consumes 30-50 m^3/day, whereas dairy B and C consumes 20 m^3/day and 50 m^3/day fresh water respectively. Dairy A uses municipality water as well as ground water whereas dairy B and C relies only on municipality water. They spend a huge amount, dairy A-1 lakh per month and dairy C-13 lakh per month in procuring water from municipality. Depending upon the purpose of the use, water softeners are added and Reverse Osmosis (RO) treatment is given to the water. The reject water of RO is in huge quantity (around 60-70%) and is not brought to the use again.

Even the quantum of wastewater generated by each of the dairies is also huge. The silos, machineries, equipment, processing units and packaging units are washed every 6 hours or once or twice in a day depending on the use. Around 3 lakh litres/ day wastewater is generated in washing of cans. Cleaning-In-Place (CIP) process is used for the cleaning and maximum fresh water is consumed in this process which amounts to 10-20% or about 50-60 KL/day of fresh water. In human activities, wastewater generated by dairy A and B is 25-30 m^3/day and 15 m^3/day respectively. The product wastewater such as whey is generated while processing paneer/chakka or cheese. Approximately 800-900 L whey is generated in processing 1000 L of milk and generating 200-100 kg paneer. This whey is acidic in nature and not reused any further in any of the dairies. It is also a major contributor of organic matter to the wastewater. Approximately 1600 litres of waste brine solution is generated in manufacturing of cheese and paneer. Large quantity of buttermilk generated during manufacturing of table butter is also discarded without any reuse. For manufacturing skim milk about 70-80% water is evaporated and wasted.

Fig 5 shows the installed capacity of effluent treatment plant (ETP) at different dairies and average quantity of wastewater effluent treated at these dairies. Combination of aerobic and anaerobic method is used for the treatment along with sand filter, carbon filter, UV and water softeners at the end stage depending on the use. Dairy A generates about 20 m^3/month of sludge from the ETP waste and 15 m^3/day of biogas energy. Dairy B and C do not generate any energy from their ETP. After checking the effluent parameters of the treated wastewater, it is reused on premises

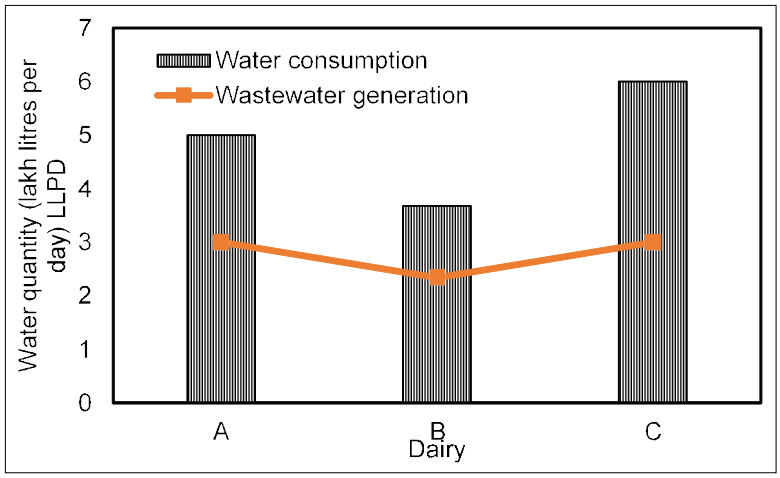


Fig 4: Water consumption and wastewater generation by different dairies.

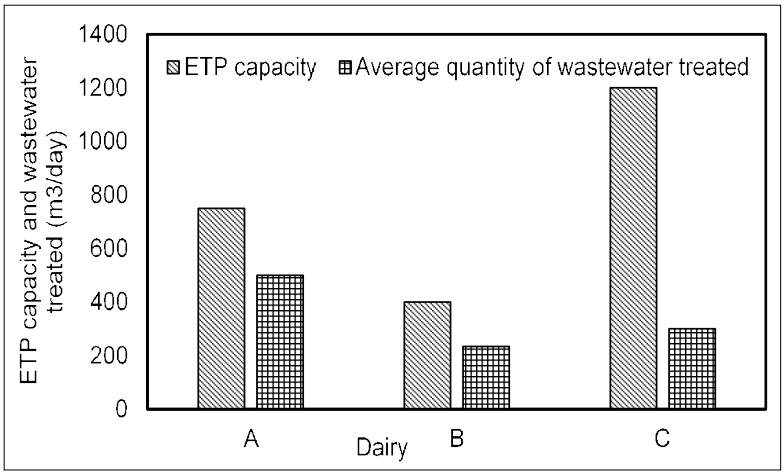


Fig 5: ETP capacity of different dairies and average quantum of wastewater treated.

Table 4: Characteristics of wastewater.

Parameters	Dairy A		Dairy B		Dairy C		Permissible range
	Influent	Treated effluent	Influent	Treated effluent	Influent	Treated effluent	(EPA, 1986 rules)
pH	8.2	7.8	8.0	7.0	9.82	7.79	6.5-8.5
TSS (mg/l)	3000	40	NA	5.0	276	8.0	150
TDS (mg/l)	1300	1210	480	820	1050	566	-
BOD (mg/l)	950	20	300	5	330	45	100
COD (mg/l)	1760	40	960	28	901	117	250

itself for non-potable uses like for washing, gardening, cleaning of floors and washing of vehicles. The sludge is reused as manure for the gardening purpose. Dairy A consumes 1.74 KW/litre of energy for treatment of wastewater. Approximately 850-900 KW/day of total energy is spent in treatment of dairy A wastewater while dairy B spends 29196 unit/month of electricity.

The data of Table 4 confirms that the effluent is treated and discharged into the water body only after bringing the contaminants within the prescribed permissible range.

Energy consumption

Different dairy states different process consumes maximum energy in their plant. Proper figures of how much electricity is consumed per month for different process is not made available by dairies. Dairy A says SMP production consumes maximum energy while Dairy B has homogeniser and Dairy C has refrigeration process consuming maximum energy. Dairy A and B uses briquettes as alternative energy source for boiler while dairy C adapts solar as alternative technology. Improving and supporting such initiatives will definitely improve productivity of dairy industry. Same mindset and efforts should be applied for recovery and treatment of wastewater.

CONCLUSION

This study helps to understand the entire dairy operations, processing, manufacturing, storage, distribution of various dairy products and factors to be dealt to improve the dairy productivity. Huge quantity of varied milk and milk products like dahi, paneer, cheese, cream, ghee, lassi, plain butter milk, masala buttermilk, Skimmed Milk Powder (SMP), sweets etc are manufactured in all of the dairies. About 2.7 litre water is required for processing per litre of milk and average wastewater is generated in the ratio of 2:1. The thermal process like evaporation of milk is adopted for the product concentration and 82% water is evaporated in manufacturing SMP. Average total quantity of fresh water consumed for various dairy activities is between 5-6 LLPD. Approximately, 800-900 litres of whey waste stream is generated in dairy in manufacturing of 200-100 kg panner by processing 1000 litres milk. Considerable amount of wastewater, approximately 3 LLPD is generated in processing of various products and cleaning, washing and in CIP process. ETP is installed in each of the dairy and some portion of the treated wastewater is reused only for non-potable purposes. No provision is made for reuse, recovery or separate treatment of highly organic whey, buttermilk or another dairy product wastewater. Huge amount of money and energy is spent in procuring fresh water. Around 900 KW/ day of energy is spent for wastewater treatment. Use of briquettes and solar is the alternative technology adopted to fulfil energy requirements in some dairies.

Looking forward, the Indian dairy market is expected to exhibit strong growth during the next five years. It is important to develop networks to promote processed food and

beverages based on milk, have well managed cold chain facilities to minimize wastage of resources and organize this sector. Large amount of fresh water and energy is consumed and wasted and simultaneously massive quantity of wastewater is generated in this sector. This has a large environmental footprint. Energy optimisation and management of dairy plant to control the energy consumption will help to achieve the overall efficiency of this industry. Awareness, training, research and development of minimising and utilising the waste can certainly prove to be revolutionary for growth of this industry as well as the Indian economy.

Data availability statement

All the data generated during this study is enclosed in this manuscript.

Conflict of interest: None.

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